Laboratory Evaluation

IQAir AirVisual Pro $PM_{2.5}$ Sensor

South Coast AQMD

AQ-SPEC
Air Quality Sensor Performance Evaluation Center

Background

Three **IQAir AirVisual Pro $PM_{2.5}$** sensors (units IDs: 4VW9, WLL6, and X44P), previously field tested at the SCAQMD Rubidoux fixed ambient monitoring station (08/02/2017 to 10/05/2017) under ambient environmental conditions, have now been evaluated in the SCAQMD Chemistry Laboratory under controlled artificial aerosol concentration/size range, temperature, and relative humidity conditions.

IQAir AirVisual Pro Sensor (*3 units tested*):

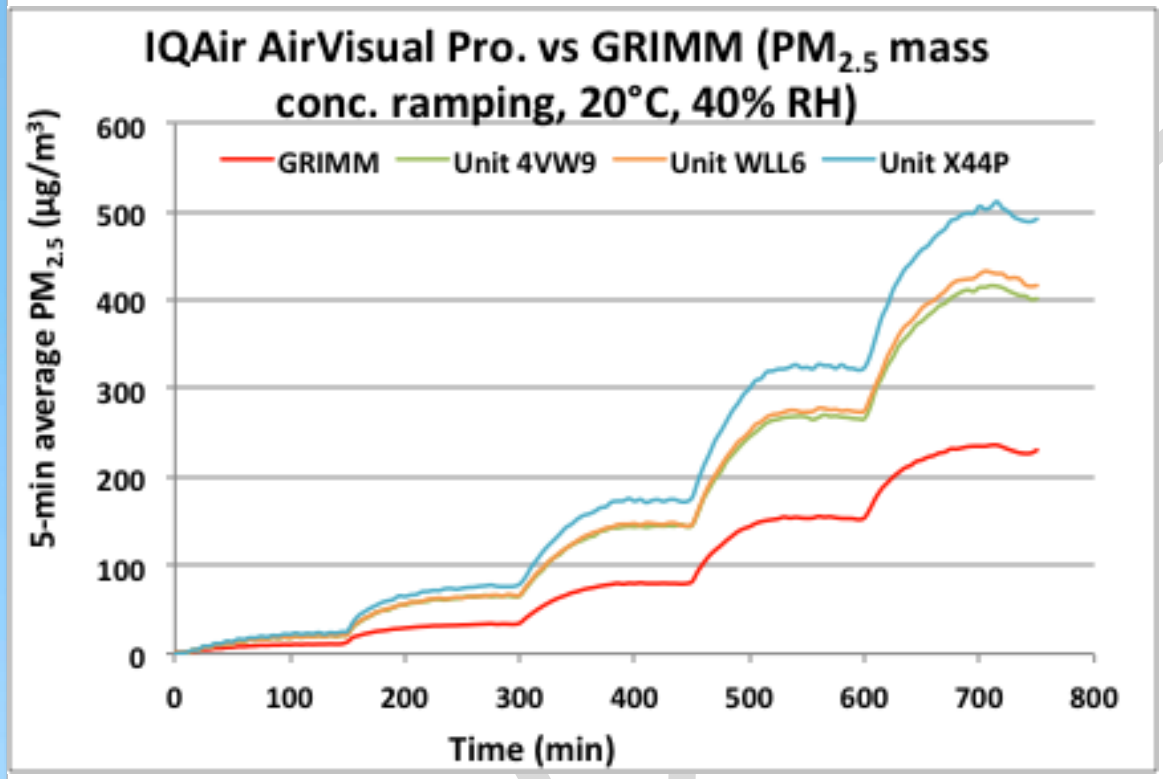
- $PM_{2.5}$ (µg/m^3) (optical; non-FEM)
- PM_{10} (µg/m^3) (optical; non-FEM)
- CO_2 (ppm)
- VOC (ppb)
- Unit cost: $269 USD
- Time resolution: 10 seconds
- Units IDs: 4VW9, WLL6, X44P

IQAir AirVisual Pro

GRIMM (*reference method*):

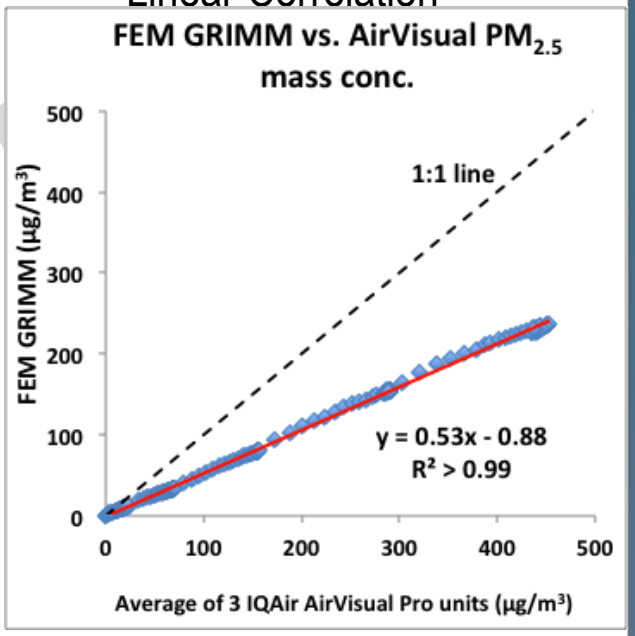
- Optical particle counter
- FEM $PM_{2.5}$
- Uses proprietary algorithms to calculate total PM, $PM_{2.5}$, and PM_1 mass conc. from particle number measurements
- Cost: ~$25,000
- Time resolution: 1-min

IQAir AirVisual Pro vs FEM GRIMM ($PM_{2.5}$ mass; 5-min mean)



- The three IQAir AirVisual Pro tracked well with the concentration variation recorded by FEM GRIMM in the concentration range of 0-250 µg/m^3.

Linear Correlation



- Three IQAir AirVisual Pro sensors showed excellent correlation with GRIMM $PM_{2.5}$ mass conc. ($R^2 > 0.99$).
- IQAir AirVisual Pro sensors overestimated the GRIMM $PM_{2.5}$ mass conc;, with a slope of 0.53.

$PM_{2.5}$ Accuracy: IQAir AirVisual Pro vs. GRIMM

- Accuracy (20 °C and 40% RH)

Steady State (#)	Sensor mean ($\mu g/m^3$)	GRIMM ($\mu g/m^3$)	Accuracy (%)
1	21.3	10.9	5.2
2	69.0	33.5	-6.2
3	154.6	79.3	5.0
4	288.6	153.0	11.4
5	440.0	228.5	7.4

- The three IQAir AirVisual Pro sensors overestimated FEM GRIMM $PM_{2.5}$ mass concentration over the concentration range of 0-250 $\mu g/m^3$. Therefore, according to the calculation below, IQAir AirVisual Pro sensors have low accuracy compared to FEM GRIMM.

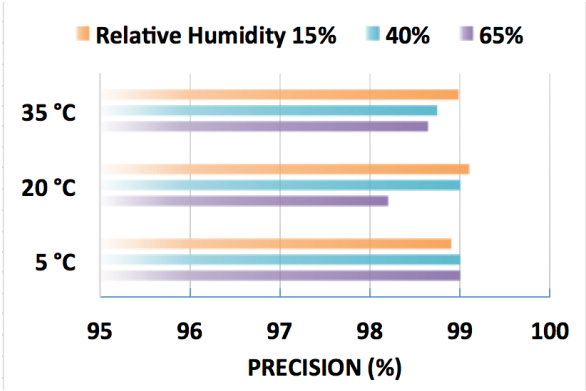
IQAir AirVisual Pro Data Recovery and Intra-model variability

- Data recovery for $PM_{2.5}$ mass concentration from Unit 4VW9, Unit WLL6, and Unit X44P was 100%.
- Low $PM_{2.5}$ measurement variations were observed among the three IQAir AirVisual Pro units.

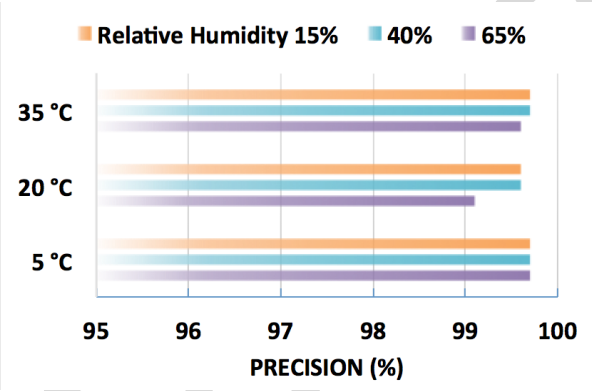
$PM_{2.5}$ Precision: IQAir AirVisual Pro

- Precision (Effect of $PM_{2.5}$ conc., Temperature and Relative Humidity)

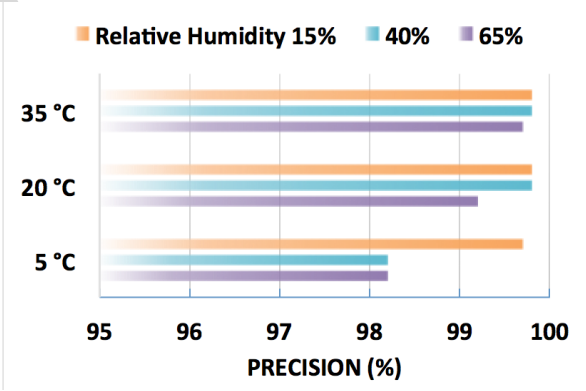
Low conc.



Medium conc.

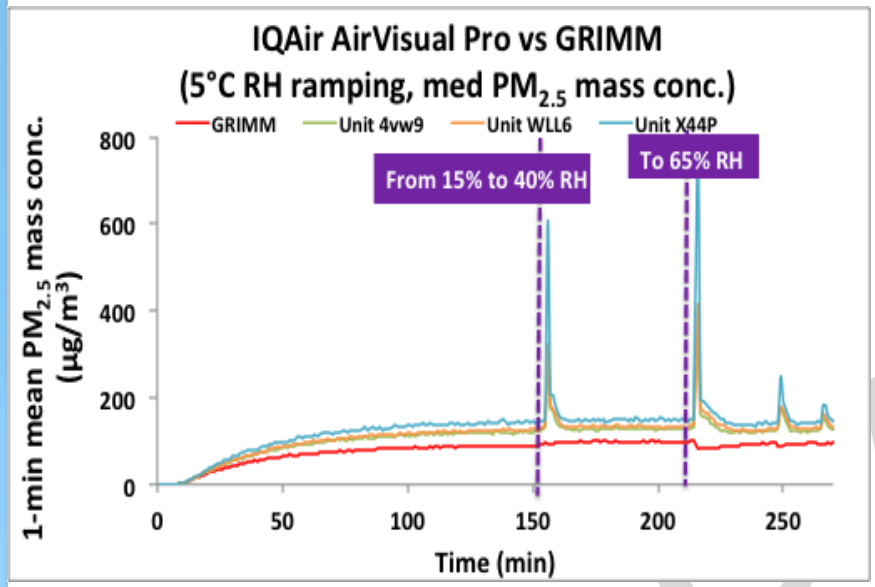


High conc.

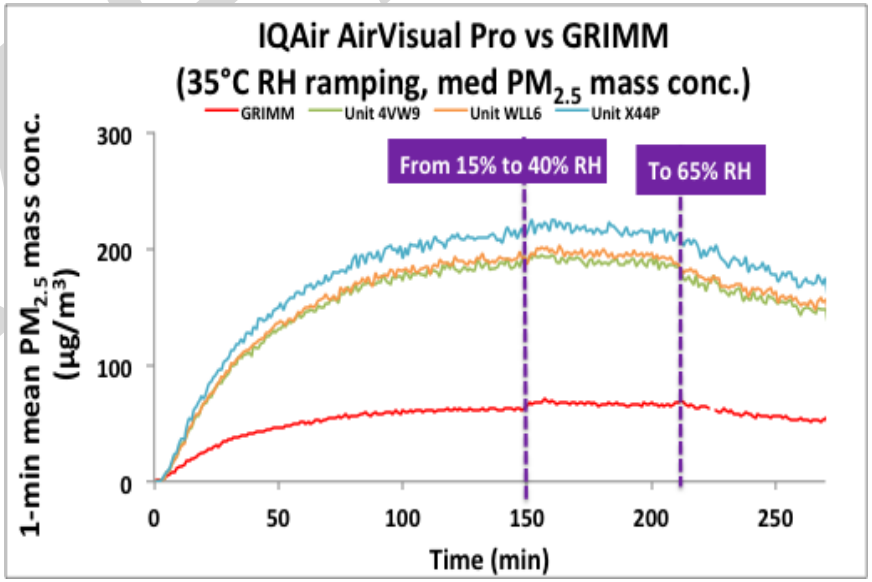


- Overall, the three IQAir AirVisual Pro sensors showed high precision for all combinations of low, medium and high $PM_{2.5}$ conc., T, and RH over a FEM GRIMM $PM_{2.5}$ conc. range of 0-250 µg/m^3.

IQAir AirVisual Pro Climate Susceptibility



Low Temp - RH ramping
(medium conc.)



High Temp - RH ramping
(medium conc.)

Discussion

- **Accuracy**: Overall, the three IQAir AirVisual Pro sensors showed low accuracy, compared to the FEM GRIMM for $PM_{2.5}$. IQAir AirVisual Pro sensors overestimated FEM GRIMM $PM_{2.5}$ readings in the laboratory experiments.

- **Precision**: The IQAir AirVisual Pro sensors showed high precision for all test combinations ($PM_{2.5}$ concentrations, T and RH).

- **Intra-model variability**: Low intra-model variability was observed among the IQAir AirVisual Pro sensors.

- **Data Recovery:** Data recovery for $PM_{2.5}$ mass concentration was 100% for all units tested.

- **Linear correlation**: The three IQAir AirVisual Pro sensors showed very good correlation/linear response with the corresponding FEM GRIMM $PM_{2.5}$ measurement data ($R^2 > 0.99$) for mass concentration range between 0 and 250 $\mu g/m^3$.

- **Climate susceptibility**: For all temperature and relative humidity combinations, the climate conditions had minimal effect on the IQAir AirVisual Pro's precision. IQAir AirVisual Pro exhibited huge spikes at the set-points of RH changes at low temperature (5°C) for all PM concentrations, smaller or no spikes were observed at higher temperatures.